# Short Communications

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## Juvenile Dispersal of Madagascar Fish-Eagles Tracked by Satellite Telemetry

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The Madagascar Fish-Eagle (*Haliaeetus vociferoides*) is critically endangered (Stattersfield and Capper 2000) with a small population limited to wetland habitats on Madagascar's western seaboard (Rabarisoa et al. 1997). Observations of extra-pair adults at the nest and juveniles in the territories of breeding pairs (Watson et al. 1996, 1999) suggest unusual behaviors that may occur as a result of overcrowding in limited suitable habitat, or if innate, may reduce the species' ability to disperse into unoccupied habitat. In addition to the behavioral and evolutionary significance of understanding these observations, the cause and consequence of this behavior may affect conservation interventions intended to prevent the species' extinction. We report the results of a pilot study to measure the movements and habitat use of fledglings after they left parental territories to better understand post-fledging dispersal (Rafanomezantsoa 1998) and the occurrence of extra birds at the nest, and to assess the effect on dispersal of release of captive-raised birds (Watson et al. 1996, 1999, Rafanomezantsoa and Kalavaha 1999).

The movements of raptors have been investigated for decades mainly by banding, direct observation in limited areas, or tracking using VHF radios (Meyburg and Meyburg 1999). Recently, satellite telemetry has provided a method that makes possible the global location of birds over an extended period. Satellite telemetry was considered the method of choice to study juvenile dispersal in Madagascar Fish-Eagles which may reach maturity at 3–4 yr of age. In addition to the extended study period, juveniles were expected to move distances greater than we could follow with conventional VHF-radio telemetry because much of their range is inaccessible, especially during Madagascar's wet season when lowlands may flood (Rafanomezantsoa 1997).

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### Methods

This study occurred in coastal floodplain wetlands of western Madagascar between the Manambolo River (19°15′S, 44°30′E) and Soahany River (18°40′S, 44°30′E), about 300 km west of the capital, Antananarivo. This area lies within the Western Malagasy phytogeographical region (Humbert 1954), which is characterized by annual rainfall from 1000–2000 mm, monthly mean temperatures above 20°C, and elevations less than 800 m. The wet season begins in October or November and lasts through March. The dry season begins in May and lasts through September or October. The climax vegetation is tropical dry deciduous forest, but savanna grasslands, maintained by burning, dominate the landscape (Guillaumet 1984). Most lakes in the region are floodplain lakes whose surface area varies considerably between wet and dry seasons (Kiener and Richard-Vindard 1972).

During the 1997 breeding season (May–December), Platform Transmitter Terminals (PTT100 Series®; Microwave Telemetry 2000, Inc., Columbia MD) with antennas fixed at 45°, were mounted with a backpack style harness on two fledgling fish-eagles. One transmitter (PTT No 3482) was mounted on a female that was rescued from an aggressive sibling, raised in captivity, and released at fledging age (Watson et al. 1996, 1999). This bird was released by hacking (a falconry term for the process of release to the wild; Cade 2000) into unoccupied, suitable habitat at Lake Mangily (18°50′S, 44°34′E). The second PTT (No. 3480) was put on a male that fledged naturally from a fish-eagle pair on Lake Ankerika (19°03′S, 44°27′E), about 65 km south of the first. PTTs were programmed for 8 hr on, 24 hr off for six cycles; 8 hr on, 96 hr off for 84 cycles; and 8 hr on, 240 hr off for the remaining life of the transmitter, to gain more frequent locations of movements made in the first year, followed by less frequent locations for the remaining life of the PTT, which we expected to be at least 4 yr.

Satellite telemetry uses the ARGOS Data Collection and Location System (Meyburg et al. 1995). ARGOS assigns PTT locations a grade according to calculated precision. We used only locations graded as within 1000 m of actual position. ARGOS reports two locations, one being a spurious mirror of the true location. We deduced the true location using either concurrent visual observations, likelihood of sequential locations, or known habitat at each location. Locations were plotted in chronological order on a topographical 1:100 000 map. The program Ranges IV® (Kenward 1990) was used to calculate distances moved and range areas based on minimum convex polygons (MCP) around locations.

## RESULTS

PTT No. 3480 on the male operated for 282 d, from 1 December 1997–8 September 1998, providing 70 usable locations. From these locations, the total MCP range of the male was 1040 km$^2$ (Fig. 1). Between the fledging date on 13 October 1997 and 17 April 1998 (186 d), the male moved in a relatively small area around its nest site. During the wet season, from December–March, the male visited small lakes and flooded lowlands to the south and southeast of its nest site along the Manambolomaty River and Lakes Kakobo and Antsohaly, covering an area of 156.4 km$^2$. By 24 April 1998, the male had moved north-northwest with one location near Lake Mangily (the female's release site) on the way. For 76 d at the beginning of the dry season, from 13 May 1998–28 July 1998, the male was located in the vicinity of the Soahanina River estuary, and associated ponds and mangroves, ranging over an area of 540.5 km$^2$. The maximum distance recorded from its nest was 51 km. By 5 August 1998 and through 8 September 1998, when the last usable transmission was received, the male was located again in the vicinity of the nest where his parents were raising a nestling.

The PTT on the female operated for 348 d, from 15 October 1997–28 September 1998, providing 40 usable locations (Fig. 2). We received 21 usable locations from 15 October 1997–22 November 1997 when the PTT ceased transmitting for unknown reasons. It then re-started 80 d later on 11 February 1998 and we received another 19 usable locations through 28 September 1998. About 95% of usable fixes were <5 km from the release site. Direct observation confirmed that the bird moved around Lakes Mangily and Samy until field observations ended 13 March 1998 due to inaccessibility from flooding. The maximum distance recorded from the release site was 8.2 km and the mean distance was 2.6 km. The female's MCP range was 45 km$^2$.

## DISCUSSION

Usable locations for the male were sufficient to determine several aspects of the bird's movement. Locations were usually received 10 or more days apart, which limited the amount of detail that could be gained from them. Initial movements of the naturally fledged male were distances of 5–18 km to sites that may be visible to a soaring bird from its natal site. The male made one large movement of short duration 51 km to the northwest, where he remained for 76 d, making successive short movements, until returning to his natal site. All areas visited were without territorial, breeding pairs. The male did not visit prominent wetland areas within his MCP range where human disturbance was high, such as Lakes Bemamba and Antsohaly.

The released female's range during the wet season, as water flooded the surrounding lowland areas, included Lakes Mangily and Samy, other small lakes, and a portion of the Miharana River. Compared to the male, the female made only very short movements around the release site While it is possible that the low number of usable locations influenced her measured range area, results were spread throughout a similar period to those of the male and observations by our field team confirmed her locations during much of the study period.

The differences in movement patterns of the male and female are interesting. They may be related to sexual differences in behavior, but there are a number of other factors that could influence dispersal. For example, naturally-raised and fledged compared with captive-raised and released by hacking might affect their behavior. Social interactions with neighboring conspecifics, the naturally fledged male had at least 10 territorial pairs nearby; whereas, the female had only one resident pair within 5 km, which could have caused a difference in dispersal behavior. Also, distribution of food during the wet-season floods might influence movements.

Habitats visited by both eagles were lakes, rivers, mangroves, and lowlands temporarily flooded during the wet season. We assume that movements of fledglings were made in exploration of suitable foraging habitat because there was no seasonal pattern to the movements, and they were of short distance and duration relative to the species' capacity for flight.

Despite the potential of satellite telemetry to track birds for up to 4 yr, because no signal was detected from the PTTs after about 18 mo, we were unable to learn more about the occurrence of extra birds at the nest beyond the observation that the male returned to its parent's territory about 10 mo after fledging and remained there at least a month while the adults were caring for a nestling. Since this study, direct observation of banded birds, and molecular studies of their genetic relatedness, have revealed far more information (Tingay 2000, Tingay et al. 2002).

Tracking additional birds to increase sample size needed to compare dispersal between naturally-fledged and captive-reared and released juveniles, and document habitat use during dispersal, has not been attempted. The practical difficulties and cost of captive rearing in Madagascar, and the cost of satellite telemetry, precluded further study. Few studies have been done on post-fledging dispersal in raptors (e.g., Walls and Kenward 1994) or comparison between captive-raised and naturally-fledged birds (e.g., Amar et al. 2000) probably for similar reasons. As satellite telemetry becomes more efficient and affordable, these areas of study may benefit.

Satellite telemetry provided us with a level of coverage and continuity, especially for long-distance movements, that we could not have achieved for the male using con-

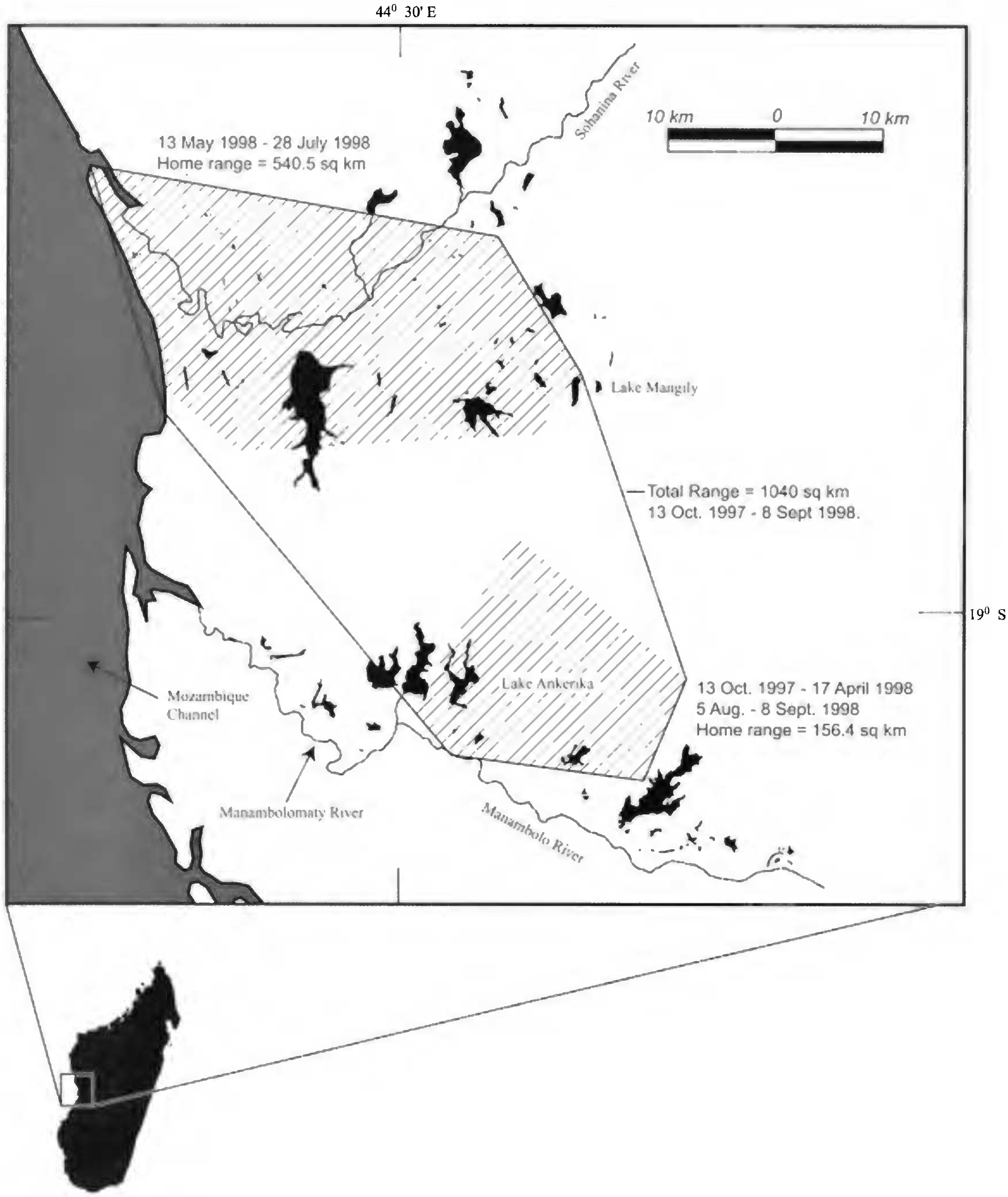


Figure 1. Chronological movements and minimum convex polygon range of the male Madagascar Fish-Eagle fledged from a nest on Lake Ankerika.

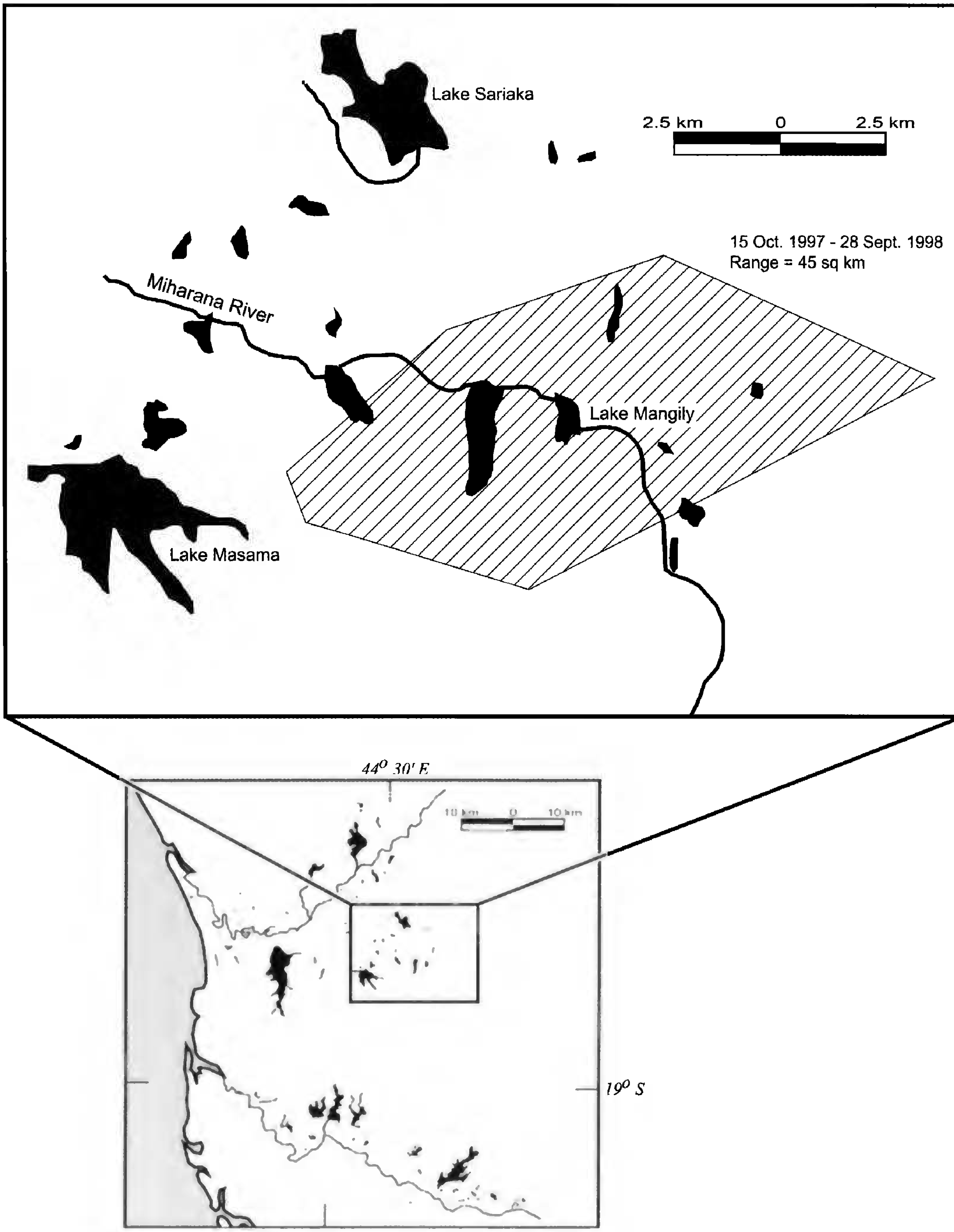


Figure 2. Minimum convex polygon range of the captive-reared female Madagascar Fish-Eagle released by hacking at Lake Mangily.

ventional VHF radios and tracking from the ground. We may have achieved similar results by VHF-radio tracking from an aircraft, but lack of landing fields and fuel in the study area precluded this approach. The programmed on-off cycle of the transmitters provided fewer useful locations than we expected. A longer (e.g., 12–24 hr) on-cycle might have generated more usable locations in these birds that were more sedentary than migrating raptors. For example, two migrating Bald Eagles (*Haliaeetus leucocephalus*) with PTTs programmed for 8 hr on, 16 hr off, and 4 hr on, 44 hr off cycles generated 205 fixes in 136 d and 27 fixes in 119 d, respectively (Grubb et al. 1994). A migrating Wahlberg's Eagle (*Aquila wahlbergi*) with a PTT programmed for 8 hr on, 134 hr off generated 104 locations in 234 d (Meyburg et al. 1995). A 12–24 hr on-cycle would increase the chance of satellites passing over an eagle in optimum position (such as in flight) to receive the transmitter's signal. Transmission of usable locations ceased for unknown reasons well before their anticipated 4-yr lifespan. Unexplained periods of no data received added to our uncertainty of the birds' movements.

We believe satellite telemetry is valuable for tracking the movement of large birds of prey; however, there are several limitations. The accuracy of locations within the PTT's operational period varied from day to day. The precision of the location is known to be affected by several satellite parameters and by the orientation, location, and movement of the transmitter. PTTs are at present larger and less streamlined than conventional VHF transmitters, and require antennas that protrude at a 45° angle rather than contour down the back and the tail of the bird. Also, PTTs are substantially more expensive, though this cost may compare favorably with the cost of data collection from VHF radios which require personnel in the field and logistical support.

Resumen.—En 1997, colocamos radio transmisores a dos polluelos de águilas pescadoras de Madagascar (*Haliaeetus vociferoides*) para estudiar sus movimientos y uso de hábitat durante la dispersión post emplumamiento. El macho partió naturalmente del nido de sus padres durante Octubre y nosotros liberamos la hembra criada en cautiverio el 15 de Octubre. El rango del águila macho fue 1040 km$^2$ entre el 1 de noviembre de 1997 y el 8 de septiembre de 1998 (70 localizaciones) y se movió una distancia máxima de 51 km desde su área natal, al norte del río Soahanina, El comenzó moviéndose largas distancias (>5 km) el 16 de Diciembre de 1997, permaneció en la vecindad del estuario del río Soahanina por 76 días, entonces retorno a la vecindad del nido (<5 km) el 5 de Agosto de 1998. El rango de la Hembra fue 45 km$^2$ entre el 15 de Octubre de 1997 y el 28 de Septiembre de 1998 (40 localizaciones) y se movió una distancia máxima de 8.2 km desde el sitio de liberación. Los ríos, lagos, manglares y zonas bajas temporalmente inundadas durante la temporada húmeda fueron visitados por ambas águilas. Sugerimos que los movimientos de los volantones se hicieron para explorar hábitats de forrajeo adecuados, ya que no hay un patrón estacional para los movimientos, y fueron relativamente de corta distancia y duración con respecto a la capacidad de vuelo de la especie.

[Traducción de César Márquez]

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